International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 3, March-April 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Improve Mechanical Properties of Self-Compacting Concrete Using Industrial By-Product

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ABSTRACT

Concrete being the most important artifical cloth used on the planet is requiring true nice of aggregates in big volumes. The availability of herbal coarse combination is depleting daily because of infinite call for in infrastructure industry. Aggregates are the primary element of concrete occupying 70-80% of its extent and exert a great impact in concrete properties. A want changed into felt to become aware of capability opportunity supply of coarse combination to satisfy the destiny increase aspiration of infrastructure industry. Use of by-merchandise together with slag, sludge from the metallurgical industries as filler substances in concrete allows to preserve herbal sources as an economically wonderful option. Slag, an commercial spinoff of metallic and iron smelting operations, may be recycled as it has extended always with the improvement of the metallic industry. In many applications, because of its precise bodily structure, slag outperforms the herbal combination for which it's miles used as an exchange combination cloth in concrete. Several research proved that using metallic slag in concrete as combination improves the mechanical and sturdiness properties. A only a few researchers had been finished concerning the usage of Electric Arc Furnace Oxidizing Slag (EAFOS) in concrete. EAFOS is an commercial spinoff acquired from the metallic production industry. EAFOS gives excessive applicability as an combination for concrete because of its CaO and SiO2 contents. Therefore, it's miles growing interest as a recycled useful resource that might mitigate the environmental pollutants on account of the gathering of herbal aggregates and offer a feasible option to the depletion of herbal aggregates.

How to cite this paper: Veeru Kumar Gupta | Dr. Abhay Kumar Jha | Dr. Rajeev Singh Parihar "Improve Mechanical Properties of Self-Compacting Concrete Using Industrial By-Product" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-3, April 2022, pp.911-915, URL: www.ijtsrd.com/papers/ijtsrd49626.pdf

IJTSRD49626

KEYWORDS: *concrete, relationship, investigation, hardened, compressive strength, flexural strength*

I. INTRODUCTION

Concrete being the most important artifical fabric used in the world is requiring properly nice of aggregates in huge volumes. The availability of herbal coarse mixture is depleting each day because of endless call for in infrastructure industry. Aggregates are the principle aspect of concrete occupying 70 - 80% of its extent and exert a extensive have an impact on in concrete residences. A want became felt to discover cappotential opportunity supply of coarse mixture to fulfil the destiny boom aspiration of infrastructure industry. Use of via way of means of- merchandise inclusive of slag, sludge from the metallurgical industries as filler substances in concrete allows to preserve herbal sources as an economically tremendous option. Slag, an business derivative of metallic and iron smelting operations, may be recycled as it has extended always with the improvement of the metallic industry. Big metallic flowers in India generate approximately 29 hundreds of thousands of tonnes of waste fabric annually. Slag reduces porosity and permeability of soil, for this reason growing the water logging trouble, if it's far used as earth filling fabric. Since huge portions of those styles of wastes are generated daily, they're taken into consideration intricate and risky for each the factories and the surroundings. Disposing the metallic slag is a completely extreme trouble which may be decreased via way of means of utilising the

slag as an trade to aggregates in concrete production. The slag in particular generated at some point of the iron and metallic making method has many crucial and surroundings pleasant usages. In many applications, because of its particular bodily structure, slag outperforms the herbal mixture for which it's far used as an trade mixture fabric in concrete Electric Arc Furnace Oxidizing Slag (EAFOS) is an business derivative acquired from the metallic production industry. It is produced in huge portions at some point of the metallic making operation. EAFOS is growing interest as a recycled aid that would mitigate the environmental pollutants attributable to the gathering of herbal aggregates and offer a possible method to the depletion of herbal aggregates. The use of EAFOS as aggregates for structural concrete now no longer simplest protects the surroundings, however additionally reduces expenses of concrete. EAFOS as an mixture have focussed its suitability primarily based totally at the fabric residences of the slag. A few research had been finished for tested the traits of concrete with EAFOS as an mixture. The latest research had been proved that the mechanical residences of concrete had been advanced while EAFOS are used as aggregates in structural concrete. Investigations had been performed to take a look at the traits of regular grade of concrete with EAFOS as an mixture and proven advanced bond overall performance than the herbal mixture. Self-compacting concrete (SCC) is one of the contemporary-day concrete in particular evolved in which guide compaction isn't always promising and additionally in dense reinforcement structural elements. The self-go with the drift of sparkling concrete is the necessary requirement for SCC and subsequently the suitability of EAFOS as coarse mixture in SCC needs to be tested earlier than the usage of in SCC. However, the reviews at the suitability of EAFOS as coarse mixture in SCC are limited. Hence, the sparkling concrete residences of SCC with EAFOS as mixture inclusive of flowing, filling and passing cappotential had been tested. In addition, the hardened concrete residences of SCC with EAFOS inclusive of density, compressive energy, flexural energy, modulus of elasticity and ultrasonic pulse velocity (UPV) had been investigated and as compared with the effects of regular concrete. The courting among the mechanical residences of concrete became arrived and additionally appropriate fashions had been evolved for predicting the compressive energy of SCC the usage of UPV effects. The suitability of EAFOS in SCC became tested primarily based totally at the sturdiness primarily based totally residences inclusive of permeability research and chemical ingress research. The ductility index of EAFOS in SCC became evaluated to recognize the overall performance of RCC beam beneathneath flexural load. The research became performed with 50% and 100 FOS mixture. There are collection of concrete taken into consideration for research purpose. The collection-I treated regular concrete and the collection-II treated SCC. Three combos of concretes inclusive of M20, M30 and M40 grade had been taken into consideration in each collection of concrete.

II. LITRATURE REVIEW

Alizadeh et al. (2003) conducted an investigation to evaluate the effect of electric arc furnace steel slag on hardened concrete and concluded that the steel slag aggregate concrete achieved higher values of compressive strength, flexural strength and modulusof elasticity when compared to the conventional aggregate concrete. Maslehuddin et al. (2003) carried out a research work to compare the performance of steel slag aggregate concrete and crushed limestone concrete and concluded that the compressive strength ofsteel slag aggregate concrete was marginally better than that of crushed limestone aggregate concrete. However, the tensile strength of steel slag concrete was not significant. Manso et al. (2004) presented a study in which EAFOS was used to obtain concrete of better quality and concluded that EAFOS aggregate concrete can be achieved higher values of compressive strength, tensile strength and flexural strength and elastic modulus compared with normal aggregate concrete. Manso et al. (2006) examined the durability performance of EAF slag concrete and the results show that the performance of EAF slag concrete is similar to the traditional concrete in terms of its strength but slightly less in terms of durability.

Lin et al. (2007) investigated the compressive strength of concrete with differentcoarse aggregate contents and conducted Ultrasonic Pulse Velocity (UPV) tests. The results proposed the UPV and strength correlation for the concrete having different contents of coarse aggregate.

Ulucan et al. (2008) investigated the effects of different types and dosages of mineral admixtures on the correlation between UPV and compressive strength for SCC. Different proportions of FA and SF were used for replacement of cement and found the exponential correlation between UPV and compressive strength with different constants for each level of cement replacements.

Solis and Moreno (2008) conducted investigation to evaluate the strength of concrete made with crushed limestone aggregate obtained in the Yucatan Peninsula based on UPV and predicted model with

exponential relationship between compressive strength and UPV.

Pellegrino and Gaddo (2009) conducted an investigation to substitute the natural aggregates with oxidizing electric furnace slag in traditional concrete. The results mentioned that the concrete made with oxidizing electric furnace slag showed good strength characteristics and reported that the compressive strength increases up to 21% in the case of 100% substitution of slag as coarse aggregate and 50% of fine aggregate.However the slag should be stored and aged outdoors in advance and exposed to natural moisture for various weeks in order to achieve the chemical / physical stability for safe use in concrete.

Bosela et al. (2009) made an effort to quantify the influence of slag on the properties of fresh and hardened self-compacting concrete by conducting various tests such as slump flow test, V-funnel test, J-ring test, U- box test and sieve stability test along with the compressive strength test. The addition of optimum slag content of 15% seems to give good rheology of fresh SCC.

Wang (2010) expressed in a research publication that the steel slag contains oxides (CaO and MgO) that can be result in volumetric

instability (expansion) that must be dealt with through steel slag aging and quality control to ensure its appropriate use in construction and care must be taken to prevent potential steel slag expansive behavior.

Cunlin et al. (2011) conducted a preliminary investigation using EAFOS as coarse aggregate and found a higher compressive strength and lower shrinkage. Zaki et al. (2011) reported the results on the flexural behaviour of reinforced concrete beam using EAFOS as aggregate in HPC concluded that encouraging results in mechanical properties were observed compared to dolomite aggregate concrete. EAFOS based concrete showed good ductility behaviour with tension reinforcement ratio up to 3.6% and the entire beam specimen tested provided ample warning to the imminence of failure.

Papayianni (2011) carried out an investigation on the large amount of high calcium fly-ash and EAFOS in concrete and EAFOS produced a heavy concrete with a density of 2800 kg/m^3. The 28 days compressive strength increases by 20% when coarse EAFOS used as aggregate and the similar pattern was observed in spilt tensile and flexural strength and also showed significant increase in the elastic modulus. The increased strength properties with EAFOS aggregates could be attributed to the surface propertiesof EAFOS.

Kim et al. (2012) conducted a research on the characteristics of concrete with EAFOS as an aggregate and that evaluated the applicability of the slag for reinforced concrete (RC) members. The study performed bond performance between the steel bar and the concrete with EAFOS aggregates which were evaluated in order to use this new material in RC members and demonstrated superior bond performance caused by higherdensity of EAFOS.

III. METHODOLOGY

This investigation was intended to evaluate the suitability of EAFOS as coarse aggregate in FA basedbinary blended normal concrete and SCC by conducting fresh, hardened and durability properties of concrete. The details of the methodology are shown in the flow chart

Table 1 Physical properties of Cement and FA

S. No	Description of test		Cement	FA
1.	Fineness (m^2/kg)		298	294
2.	Specific gravity		3.15	2.67
3.	Bulk density (kg/m^3)		1507	723
4.	Lime reactivity (MPa)		-	3.95
5.	Initial setting time (minutes)		86	-
6.	Final setting time (minutes)		180	-
7.	Compressive strength (MPa)	3-days	28.4	-
		7-days	43.2	-
		28-days	55.1	-

Table 2 Chemical compositions of Cement and FA

Results (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LoI
Cement	22.40	5.20	3.80	61.60	1.70	1.40
FA	61.85	20.31	3.26	3.78	1.55	3.49

Table 3 Physical properties of fine aggregate

S. No.	Description of test	Fine aggregate
1.	Deleterious material (% by weight)	Nil
2.	Specific gravity	2.68
3.	Water absorption (%)	1.37
4.	Fineness modulus	2.68
5.	Bulk density (kg/m^3)	1590

IV. RESULT & DISCUSSIONS

Effects of EAFOS on Slump value of normal concrete

The fresh concrete specimens of AN20, AN30 and AN40 mix designated control concrete have the slump value of 80 mm, 90 mm and 85 mm respectively. The slump value of BN20, BN30 and BN40 mix designated concrete samples with 30% FA (B series) were found to be 95 mm, 95 mm and 93 mm respectively. The addition of 30% FA indicates that marginal increase in slump value when compared to the control mixes considered in this investigation. The slump value of CN20, CN30 and CN40 mix designated concrete samples with 50% EAF oxidizing slag (C series) were found to be 90 mm, 85 mm and 83 mm respectively and in 100% EAF oxidizing slag (D series), the slump value of DN20, DN30 and DN40 samples were found to be 85 mm, 83 mm and 80 mm respectively.

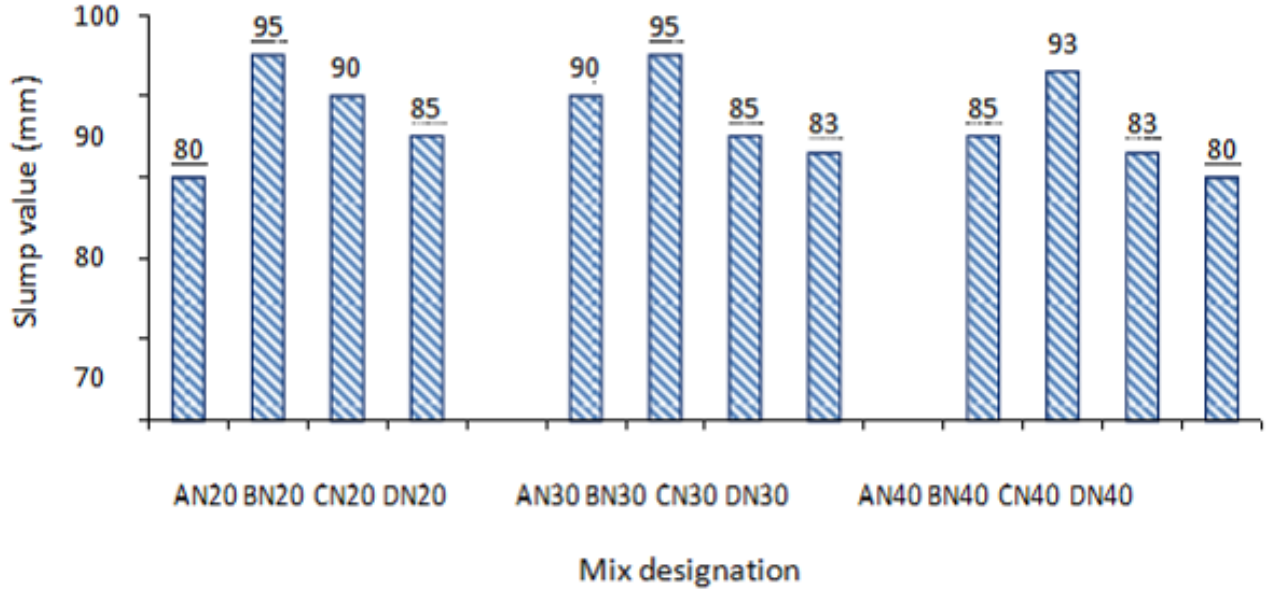

Figure 1 Slump value of normal concrete

Conclusion

- In the normal concrete mix, insignificant reduction of slump value were noticed while adding the EAFOS as coarse aggregate due to the textural characteristics such as rich in angular shape which increases the total surface area of the aggregate. Slump retention value after 30 minutes showed that the reduction in the slump ranged from 15% to 20% which indicates the workability of normal concrete are not affected by EAFOS aggregate.
- It was witnessed that the addition of 50% EAFOS instead of CA decreases the slump-flow value of the SCC and further reduction of slump flow values were observed in 100% EAFOS based designated SCC mixture when compared to 50% EAFOS due to the textural characteristics of EAFOS aggregates. However, the slump flow values of EAFOS based designated SCC mixture were within the target range (650 to 800mm) for SCC. The results of secondary indication of slump-flow were measured as the time to reach 500 mm slump-flow circle (T_{500}) in seconds and the results are satisfied the criteria for SCC of all the concrete mixtures considered in this investigation.
- The results of normal concrete samples with 50% EAFOS are higher by 4.7% and the samples with 100% EAFOS are higher by 9.5% compared to the density of the conventional concrete. The density of concrete SCC with 50% EAFOS are higher by 6.5% and the SCC samples with 100% EAFOS are higher by 11% compared to the density of the conventional concrete. The results indicated that the density of normal concrete and SCC could be increased if the conventional CA was replaced by EAFOS. 9

- The 50% EAFOS based mix C designated M20, M30 and M40 grade normal concrete specimens were resulted 28%, 17% and 10% higherthan the respective control concrete and 100% EAFOS based mix D designated M20, M30 and M40 grade normal concrete specimens were also resulted 33%, 24% and 13% higher than the respective control concrete. The increase in compressive strength could be attributed tothe strong bond between the EAFOS aggregate particles and mortar matrix due to the surface properties of EAFOS particles.
- The compressive strength of 28 days cured 50% EAFOS based mix C (CS20) specimens were 14% higher than the control concrete and 21% higher in 28 days cured 100% EAFOS based mix D (DS20) concrete specimens. The compressive strength of 90 days cured M20, M30 and M40 grade SCC specimens of mix C were 32%, 21% and 16% higher compressive strength than that of respective control concrete. It was observed in 100% EAFOS based M20, M30 and M40 grade mix D SCC specimens resulted 38%, 27% and 20% higher than the respective control concrete. The increase in the compressive strength of SCC with EAFOS could be ascribed to the strong bond between EAFOS aggregate particles and cement matrix due free flow of matrix in to the porous and rough surface of EAFOS aggregate particles.

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